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Correlated perceptions and underlying hormonal factors of bodily, facial, and vocal attractiveness, health, and physical dominance

Tobias L. Kordsmeyer [a,*], Philine A.C. Rasokat [a], Julia Stern [b], Christoph Schild [c], Lars Penke [a]

[a] Department of Psychology & Leibniz ScienceCampus Primate Cognition, University of Goettingen, Germany
[b] Department of Psychology, University of Bremen, Germany
[c] Department of Psychology, University of Münster, Germany

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ABSTRACT

Previous research has shown that attractiveness perceptions of male body parts and modalities correlate with each other. These findings support the *one ornament hypothesis*, according to which individual body parts and modalities have a common underlying latent cause and vicariously function as an indicator of genetic quality during mate choice. In contrast, the *multiple messages hypothesis* suggests that different body parts and modalities signal distinct and non-redundant information about mate quality. This preregistered study sought to replicate and extend findings on correlated perceptions of men's and women's facial, bodily, and vocal attractiveness, health, and physical dominance. Partial mediation by sex hormone levels (testosterone, estradiol) was analysed as purported mechanisms involved in the development of sexually dimorphic characteristics influencing perceptions. Facial photos, voice recordings, and 3D body scans of 165 men and 155 women were judged separately for attractiveness, health, and physical dominance by overall 400 raters. Results showed medium-sized positive correlations for faces and bodies for all three attributes, but only few significant associations of vocal with facial or bodily judgments. Correlated perceptions showed some variation by target sex. Thus, our results are more in line with the one ornament hypothesis for faces and bodies, and more with the multiple messages hypothesis for voices. No significant partial mediation by hormone levels aligning with hypotheses was found. Future studies should include further stimuli and examine additional hormonal variables to elucidate endocrine mechanisms.

1. One ornament or multiple messages?

Sexual selection theory suggests that during intrasexual competition men and women enhance their access to potential mates by submitting rivals, whereas during intersexual selection they strive for partners high in phenotypic and genetic quality (e.g. Lewis et al., 2022; Puts, 2010, 2016). Both mechanisms involve the display of traits, either to intimidate rivals or to showcase qualities as a partner and parent. The assessment of attributes like physical attractiveness (especially relevant for intersexual selection), dominance (for intrasexual competition), and health (relevant for both forms of selection) is multimodal, including visual cues like bodily and facial physical appearance (e.g. Roth et al., 2021; Watkins, 2025) and vocal characteristics (Groyecka et al., 2017). It has been proposed that cues across different body parts and modalities of an individual's phenotype are perceived redundantly as attractive, dominant, or healthy (Feinberg et al., 2008a; Gangestad & Scheyd, 2005; Moller & Pomiankowski, 1993; Watkins, 2025). According to the *one ornament hypothesis* (Feinberg, 2008; Fink et al., 2010; Thornhill & Grammer, 1999; also named *backup signals hypothesis*, Grammer et al., 2001; Smith et al., 2016; *redundancy hypothesis*, Williams & Apicella, 2023), different body parts comprise a single ornament signalling immunocompetence (potentially mediated by androgens, as suggested by the immunocompetence handicap hypothesis, but see Nowak et al., 2018 for evidence questioning immunosuppressive effects of androgens), genetic quality, reproductive potential, and hence overall mate value. This has been explained by ontogenetic mechanisms of developmental stability manifested in body and facial symmetry, and of sexually dimorphic physiological features dependent on hormonal variables. Here, an ornament is defined as a trait functional in the intrasexual competition over or intersexual pursuit of mates (e.g. Schaefer et al., 2006; Watts & Fitzpatrick, 2024). For example, an individual's somatotype (body shape and physique) is influenced by fat disposition, which is reflected in the face as well, whereas vocal characteristics are determined by formants, which in turn are related to body height and

* Corresponding author.
E-mail address: tob.kor@gmail.com (T.L. Kordsmeyer).

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mass (Watkins, 2025). These related characteristics may lead to positive correlations between multimodal perceptions (e.g. between bodies and faces or bodies and voices). In contrast, the *multiple messages hypothesis*, originally developed in birds and later applied to humans, suggesting that different modalities and body parts convey distinct and non-redundant information about an individual's mate qualities, indicating overall quality only in combination (Moller & Pomiankowski, 1993; Williams & Apicella, 2023). For example, the face may primarily convey an individual's immunocompetence and women's physical fitness as well as further cues to health, such as indicated by hair quality, face shape, skin texture and colour (which the body, given clothing in everyday life, and the voice do not signal, Henderson et al., 2016; Hinsz et al., 2001; Stephen & Luoto, 2023; Williams & Apicella, 2023). The voice may signal a woman's reproductive potential or fertility and a man's dominance (Pipitone & Gallup Jr, 2008; Puts et al., 2007), and the body may convey cues to health, immunocompetence, as well as a women's reproductive potential and parity (e.g. indicated by waist-to-hip ratio) and men's physical fitness (conveyed by shoulder-to-hip ratio and muscularity, for example, which are not immediately detectable in the face or voice, Bovet, 2019; Hönekopp et al., 2007; Pazhoohi et al., 2019; Peters et al., 2007; Stephen & Luoto, 2023; Williams & Apicella, 2023). Thus, the one ornament hypothesis predicts positive associations between perceptions of qualities based on different stimuli (body parts and modalities), whereas the multiple messages hypothesis suggests no substantial correlations (Třebický et al., 2023). Studies have reported positive correlations between perceptions of bodies and faces for attractiveness (e.g. Fink et al., 2010) and partly for dominance and health (Pereira et al., 2019; Smith et al., 2016), albeit often only in small samples. Fewer studies have investigated further modalities like voices (e.g. Röder et al., 2013; Saxton et al., 2006). Hormonal mechanisms of these correlated perceptions have been theorised but not yet investigated empirically (Feinberg, 2008; Thornhill & Grammer, 1999). Sex steroid hormones like testosterone and estradiol are theorised to influence the development of sexually dimorphic characteristics in faces, bodies, and voices that affect perceptions of attractiveness and other attributes (Schaefer et al., 2006; Smith et al., 2016). These hormonal mechanisms may explain correlated perceptions across different body parts and modalities, as suggested by the one ornament hypothesis. Thus, this study aimed to examine correlations of facial, bodily, and vocal attractiveness, health, and dominance (in our study conceptualised as physical dominance, which is close to formidability, e.g. Lukaszewski et al., 2016; in line with the differentiation from social dominance, e.g. Main et al., 2009) in large samples of men and women, as well as a possible partial mediation by sex hormones (testosterone and estradiol).

In line with the one ornament hypothesis, studies showed positive associations between perceived facial and bodily attractiveness (rs = 0.30–0.52, Fink et al., 2010; Hönekopp et al., 2007; Saxton et al., 2009; Thornhill & Grammer, 1999). Evidence for the association between facial and vocal attractiveness is somewhat mixed, with mostly significantly positive (rs = 0.08–0.63, Abend et al., 2015; Rezlescu et al., 2015; Saxton et al., 2006; Schirmer et al., 2025; Valentova et al., 2017; Wells et al., 2013; Williams & Apicella, 2023; Zäske et al., 2020) and some null associations (rs = −0.06–0.26, Oguchi & Kikuchi, 1997; Valentova et al., 2017; Wells et al., 2013; Zäske et al., 2020). Moreover, while direct evidence on bodily and vocal attractiveness is lacking, vocal attractiveness was associated with bodily measures that have been shown to correlate with attractiveness perceptions (r = 0.50 with shoulder-to-hip ratio in men, r = −0.38 with waist-to-hip ratio in women, Hughes et al., 2004; r = −0.36–-0.60 with bodily asymmetry, Hughes et al., 2002).

While most studies on the one ornament hypothesis examined perceptions of attractiveness, a few studies also investigated perceptions of further attributes like dominance or health. Cross-modal associations for these attributes are likely, since bodily and facial characteristics affecting perceived dominance or health have been shown to be jointly influenced by developmental stability and hormonal mechanisms (Fink et al., 2010; Foo et al., 2017; Groyecka et al., 2017; Van Dongen & Gangestad, 2011; Zaidi et al., 2019), and previous research has shown that at least bodily attractiveness and dominance are strongly positively associated in men (β = 0.78, Hönekopp et al., 2007). The few available studies have shown positive correlations between facial and bodily dominance (r = 0.53, Fink et al., 2010), as well as between facial and vocal dominance (framed as masculinity/femininity and the latter measured objectively as voice pitch in some studies, mostly positive correlations with rs = 0.25–0.97 with other studies rather showing negative or null correlations, Feinberg et al., 2005; Feinberg et al., 2008b; Pereira et al., 2019; Rezlescu et al., 2015; Smith et al., 2016). There is only indirect evidence for a correlation of perceived bodily and vocal dominance (e.g. body size and voice pitch, Cartei et al., 2014; Puts et al., 2012). It should be noted that correlated perceptions of dominance may be more likely for men than for women, because there was probably less sexual selection pressure on women to signal dominance, in contrast to men (Puts, 2010). Regarding correlated perceptions of health, studies only provided indirect evidence for cross-modal associations via perceived attractiveness (e.g. Grammer & Thornhill, 1994; see also review by De Jager et al., 2018). Still, bodies, faces, and possibly voices may constitute ornaments signalling health (Fink et al., 2010; Young et al., 2020). One of the few available studies reported strong positive correlations between health perceptions of faces and voices (rs = 0.70–0.91, Smith et al., 2016).

Thus, women's and men's bodies, faces, and voices may constitute single ornaments as cues to shared underlying qualities, resulting in correlated perceptions of attractiveness and possibly dominance and health (e.g. Feinberg et al., 2008a; Fink et al., 2010; Thornhill & Grammer, 1999). However, a few key questions regarding the associations of multiple cues in humans remain unresolved, especially for dominance and health. For bodily stimuli, a potential confounding factor in earlier studies which positively biases correlated perceptions of faces and bodies is skin colour. Especially in ethnically diverse samples, biases such as the own-race effect (Tanaka et al., 2004) may have inflated positive associations. Hence, this study uses 3D body stimuli free of skin colour information to examine whether correlated perceptions are robust when omitting this confound. In addition, the 3D body stimuli entail more complete cues on body shape.

2. Hormonal mechanisms

It has been theorised that correlated perceptions of attractiveness and other attributes can be explained by sex-specific steroid hormonal mechanisms, involved in the development of bodily, facial, and vocal characteristics and likely evolved under sexual selection (e.g. Smith et al., 2016). In both men and women, the development of such sexually dimorphic characteristics has been associated with steroids like testosterone and estradiol (Schaefer et al., 2006; Smith et al., 2016). For example, women's higher estradiol levels are related to higher voice pitch and to higher bodily and facial femininity (Feinberg et al., 2006; Jasieńska et al., 2004; Law Smith et al., 2006; Mondragón-Ceballos et al., 2015; Schaefer et al., 2006; Thornhill & Grammer, 1999; but see Jones et al., 2018 for a null-finding on facial attractiveness and waist-to-hip ratio). In men, mostly positive associations of testosterone levels with masculinity and health measures have been reported (e.g. Feinberg et al., 2008a; Penton-Voak & Chen, 2004; Pound et al., 2009; for mixed findings on health see Nowak et al., 2018; see Kordsmeyer, Freund, et al., 2019 for a null-finding), which may signal aggressive or dominant behaviour in intrasexual competition (Scott et al., 2013). Indeed, in men, testosterone levels may be associated with perceived attractiveness (Williams & Apicella, 2023; see Kordsmeyer, Lohöfener, & Penke, 2019 for a null-finding; see Jünger et al., 2018 for a null-result in female perceivers), dominance (Fink et al., 2010; Kordsmeyer, Lohöfener, & Penke, 2019; Smith et al., 2016), and health (Smith et al., 2016). In women, estradiol levels may be related to perceived attractiveness (Lephart, 2018; Williams & Apicella, 2023; but see Jones et al.,

2018 and Probst et al., 2016 for null-findings) and health (Fink et al., 2010; Smith et al., 2016), but may be associated negatively with dominance (Schaefer et al., 2006; Smith et al., 2016). An interaction effect of women's higher estradiol and simultaneously lower testosterone levels has been associated with greater attractiveness (Thornhill & Grammer, 1999), alternatively conceptualised and analysed as a testosterone/estradiol ratio (Probst et al., 2016; Schaefer et al., 2006). Higher levels of testosterone in men and higher levels of estradiol (and lower testosterone) in women would ontogenetically drive masculinity in men and femininity in women, respectively, and hence lead to correlated cross-modal perceptions of dominance, attractiveness, and health (Fink et al., 2010; Smith et al., 2016; Thornhill & Grammer, 1999). With lower sex hormone levels, men's masculinity and women's femininity should be more variable and relatively more influenced by other factors (e.g. genetic and environmental factors, Lee et al., 2014), leading to lower cross-modal correlations of perceptions. Hormonal levels are often economically measured as baseline or reactive (acute increases in anticipation of or during social interactions, such as in mate pursuit or intrasexual competition, Roney, 2016) levels from salivary samples (Lewis, 2006), taking salivary hormonal levels as indirect measures of hormonal organisational effects, based on the assumption of associations of adult salivary hormonal levels with purported markers of perinatal organisational effects of hormones (e.g. baseline testosterone with 2D:4D digit ratio, Klimek et al., 2014) which however was challenged by more recent null-findings (e.g. meta-analysis by Sorokowski & Kowal, 2024 on 2D:4D digit ratio). Furthermore, perceptions of attractiveness, health, and physical dominance should be influenced by hormonal correlates of health (e.g. skin and hair quality, Grymowicz et al., 2020; Zouboulis et al., 2007) and lifestyle-associated hormonal correlates (e.g. physical exercise, social status, Edwards & Casto, 2013; Cheng et al., 2018; Roney, 2016), which would in turn lead to associations of perceptions with baseline and reactive (acute increases in anticipation of or during social interactions, such as in mate pursuit or intrasexual competition, Roney, 2016) hormonal levels. More recently, methods have been developed and validated to capture baseline hormonal levels over a timespan of weeks to months from hair samples (e.g. Russell et al., 2012; Stern et al., 2022). Hence, hormonal mechanisms may be central modulators of correlated perceptions of faces, bodies, and voices as suggested by the one ornament hypothesis (Feinberg, 2008; Fink et al., 2010; Thornhill & Grammer, 1999) and were examined in this study.

3. Hypotheses

Based on earlier studies and theoretical reasoning, we hypothesised the following:

- There are positive correlations for perceptions of attractiveness, physical dominance, and health between bodies, faces, and voices of both women and men.
- The association between facial and vocal attractiveness is stronger in women than men.
- For women, we hypothesised correlations between faces, bodies, and voices for both attractiveness, physical dominance, and health to be partially mediated by estradiol levels and by the testosterone/estradiol ratio (correlations controlling for estradiol levels and or the testosterone/estradiol ratio weaker compared to bivariate correlations).
- For men, we hypothesised the correlations between faces, bodies, and voices for attractiveness, physical dominance, and health to be partially mediated by testosterone levels (weaker correlations controlling for testosterone levels compared to bivariate correlations).

4. Methods

4.1. Transparency, openness, and reproducibility

The data, analysis script, and materials are available at https://osf.io/k9fru and the preregistration at https://osf.io/q3kzf.

4.2. Facial, bodily, and vocal stimuli

As part of two larger studies involving further variables not relevant to this investigation (Jünger et al., 2018; Kordsmeyer et al., 2024), facial photographs were taken from 322 targets (two photographs each from 165 men, four photographs each from 157 women, age: $M = 23.8$ years, $SD = 3.4$, range 18–34) while standing in front of a white wall from a distance of two metres, with the participants directly facing the camera (Canon EOS 350D) and showing a neutral facial expression (cf. Thornhill & Grammer, 1999). The most suitable photo per participant (in terms of neutral facial expression and standardised head position) was chosen. One (for facial health and physical dominance ratings) or two (for facial attractiveness) male facial photographs and two female facial photographs were excluded due to issues with the photograph (poor quality) or because participants did not want their photographs to be used for rating studies, yielding final samples of 163 to 164 male facial photographs and 155 female facial photographs. All targets were scanned three times using a Vitus^{smart}XXL body scanner and AnthroScan software (both Human Solutions GmbH, Kaiserslautern, Germany). Three-dimensional models of body scans were converted into "beauty turn" videos (each lasting 8 s.), in which a body was turning around its vertical axis (Fig. 1). Four (for bodily health ratings) to 13 (for bodily physical dominance and attractiveness ratings) male body scans and two (for bodily physical dominance and health ratings) to 16 (for bodily attractiveness ratings) female body scans were excluded due to issues with the scans (e.g. poor quality) or because participants did not want their body scans to be used for rating studies, resulting in final samples of 152 to 161 male beauty turns and 141 to 155 female beauty turns (sample sizes differed between attributes due to diverging benchmarks for stimulus exclusions between data collections). To reduce strain on raters, the male and female beauty turn samples were halved into sets of between 70 and 81 videos each, which were matched for BMI to yield two sets similar in body compositions. These sets were rated by separate groups of raters (see below). For the vocal stimuli, target men were asked to describe themselves within one minute based on three positive life domains, which were self-chosen from a list of eight life domains (e.g. "sport", "humour", for details). From each recording, five seconds were

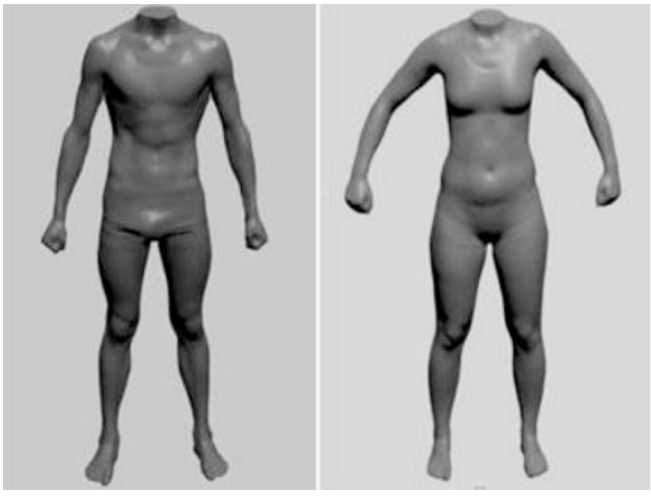

Fig. 1. Illustrative static examples of standardised male and female 3D body scans.

extracted, beginning five seconds after onset of the recording. Target women were recorded reading aloud a standardised voice passage ("rainbow passage", Fairbanks, 1960), with the second sentence being used for voice ratings (mean length of the voice stimuli = 3.50s, *SD* = 0.55 s). Since women's voices were recorded four times across their menstrual cycle (twice fertile, twice luteal phase, see Jünger et al., 2018), the recordings concurrent with the face scans from the first non-fertile session were used. That way cycle phase was standardised for female subjects. After excluding five recordings for men owing to technical issues and participants not wanting their recordings to be used further, the final vocal stimulus sets comprised 160 male and 155 female recordings. For all recordings a Line6 XD-V75 microphone was used. Sensitivity power analyses conducted using G*Power 3.1 (Faul et al., 2009) suggested that the sample sizes of at least 141 targets would allow to detect small-to-medium effect sizes of $\rho \geq 0.23$ with 80 % power at $\alpha = 0.05$. Participants signed an informed consent form and the study was approved by the local ethics committee (no. 111 for men and no. 144 for women).

4.2.1.1. Raters. Overall 228 women (age: *M* = 23.1 years, *SD* = 5.7) and 172 men (*M* = 23.2. years, *SD* = 6.0) judged target men's and women's faces, bodies, and voices in separate groups of raters per attribute and target sex (for exact distributions of rater numbers see Table 1) in exchange for monetary compensation or course credit.

4.3. Rating procedures

Rating items and response scales for facial, bodily, and vocal attractiveness, health, and physical dominance are depicted in Table 2. For facial ratings, the photos of targets' faces were presented on computer screens. Raters saw a preview of the whole sample, with each photo being displayed for 0.5 s one after another, to provide a first impression of the range of targets (men and women separately). Then, raters viewed the photos in randomised order, one at a time and for as long as they wanted, directly followed by the one rating item. For body ratings, raters watched a preview with screenshots of the whole sample (half of the sample per group of raters), with each beauty turn being displayed for 1 s one after another, to provide a general impression about the range of different bodies. Raters viewed the beauty turns in randomised order, one at a time and for as long as they wanted (minimum one full 360° turn), directly followed by the one rating item. For judgments of voice recordings, raters were equipped with headphones, seated in private workstations, and provided information on their age, sex, sexual orientation, relationship status, and whether they were enrolled as a student. Voice recordings were presented in randomised order. All ratings were conducted separately for male and female targets, based on previous findings of diverging effect sizes in cross-modal associations (Groyecka et al., 2017; Williams & Apicella, 2023).

Table 1
Distributions of rater numbers by target and rater sex for all attributes and modalities.

Stimuli and attributes	Number of raters by target and rater sex			
	Male targets		Female targets	
	Male raters	Female raters	Male raters	Female raters
Facial				
Attractiveness	–	10	20	21
Health	11	–	–	11
Physical dominance	11	–	–	11
Bodily				
Attractiveness	–	31[¥]	42[¥]	42[¥]
Health	–	21[¥]	17 [¥]	16[¥]
Physical dominance	20[¥]	–	–	20[¥]
Vocal				
Attractiveness	–	22	10	–
Health	11	–	–	11
Physical dominance	30	–	–	12

Note. [¥]These ratings were performed in 2 sets with half of the stimuli by half of the raters each.

Table 2
Overview of items and response scales for all attributes and modalities.

Stimuli and attributes	Items and response scales by target sex	
	Male targets	Female targets
Facial		
Attractiveness	"How attractive is this man?"; −5="very unattractive" to +5="very attractive"	"How attractive is this woman's face?"; −5="extremely unattractive" to +5="extremely attractive"
Health	"How healthy is this man?"; −5="very unhealthy" to +5="very healthy"	"How healthy is this woman?"; −5="very unhealthy" to +5="very healthy"
Physical dominance	"How likely would this man win a physical fight against another man?"; −5="very unlikely" to +5="very likely"	"How likely would this woman win a physical fight against another woman?"; −5="very unlikely" to +5="very likely"
Bodily		
Attractiveness	"How attractive is this man?"; −5="extremely unattractive" to +5="extremely attractive"	"How attractive is this woman?"; −5="extremely unattractive" to +5="extremely attractive"
Health	"How healthy is this man?"; −5="very unhealthy" to +5="very healthy"	"How would you rate this woman's health?"; −3="very poor" to +3="very good" (converted to 11-point scale)
Physical dominance	"How likely would this man win a physical fight against another man?"; −5="very unlikely" to +5="very likely"	"How likely would this woman win a physical fight against another woman?"; −5="very unlikely" to +5="very likely"
Vocal		
Attractiveness	"How attractive is this man?"; −5="very unattractive" to +5="very attractive"	"How attractive is this woman?"; −5="very unattractive" to +5="very attractive"
Health	"How healthy is this man?"; −5="very unhealthy" to +5="very healthy"	"How healthy is this woman?"; −5="very unhealthy" to +5="very healthy"
Physical dominance	"How likely would this man win a physical fight against another man?"; −3="very unlikely" to +3="very likely" (converted to 11-point scale)	"How likely would this woman win a physical fight against another woman?"; −5="very unlikely" to +5="very likely"

4.4. Hormone measures

Target men's baseline testosterone (aggregate from two measures across separate days to provide a more reliable trait level estimate) and testosterone reactivity (two separate measures, one immediately after engaging in a dyadic competition against a male opponent for a different study and one 20 min later, Kordsmeyer, Stern, & Penke, 2019) levels as well as target women's baseline testosterone and baseline estradiol levels (for both, means of four measures each were taken, two each in the luteal and in the fertile phase of menstrual cycle, Stern & Casto, 2024; Tsepelidis et al., 2007) were measured from saliva samples by passive drool (further details on hormone measures, see Jünger et al., 2018; Kordsmeyer et al., 2019). For further, more robust measures of baseline testosterone levels (e.g. Preinbergs et al., 2023), hair samples were taken from target women during their second and fourth lab visits (with

varying menstrual cycle phases) and aggregated to measure hair baseline testosterone (data are available from $n = 128$ women, dropouts due to levels below the limit of quantification, for details on hair testosterone measures see Kordsmeyer et al., 2019; Stern et al., 2022). All samples were shipped to and analysed by the Kirschbaum Lab at the Technical University of Dresden. Men's salivary testosterone levels and women's salivary estradiol levels were analysed using immunoassays, and women's salivary and hair testosterone levels were measured via liquid chromatography–mass spectrometry (LC-MS; for details and reasons for deviating analysis methods see Jünger et al., 2018; Stern et al., 2022). The lab reported the following coefficients of variation (CVs): salivary testosterone (nominal 0.01 ng/ml) intra-assay CV = 7.2 %, inter-assay CV = 8.6 %, hair testosterone (nominal 0.5 pg/mg) intra-assay CV = 8.1 %, inter-assay CV = 8.8 %; limits of quantification (LOQs): salivary testosterone 1 pg/ml, hair testosterone 0.08 pg/mg.

Outliers in hormonal variables were identified using the *outliers_mad* function of the R package *Routliers* (Leys et al., 2013; Leys et al., 2019; Mehta et al., 2015; Pollet & van der Meij, 2017; setting a conservative threshold of 3 mediation absolute deviations (MADs), Miller, 1991) and winsorised to the threshold of 3 MADs (14 positive outliers for men's baseline and post-competition testosterone, 13 positive outliers for women's salivary baseline testosterone, 18 for their hair baseline testosterone, 19 for their salivary baseline estradiol). Due to significant deviation from normality, all hormonal variables subsequently were log10-transformed (before transformation: Shapiro-Wilk test, Ws = 0.88–0.98, ps < 0.01, after log10-transformation: Ws = 0.98–0.99, ps > 0.12, except for women's hair testosterone: $W = 0.98$, $p = .04$). For testosterone reactivity measures, residual scores were calculated by regressing post-competition on baseline testosterone levels (using the baseline saliva sample obtained on the day of the second session, for both post-competition samples separately, cf. Burt & Obradovic, 2013; van der Meij et al., 2012). For women, the T/E ratio (e.g. Schaefer et al., 2006) was calculated by dividing salivary baseline testosterone levels by salivary baseline estradiol levels (both winsorised and log10-transformed).

4.5. Statistical analyses

Bivariate Pearson correlations were calculated to examine associations between faces, bodies, and voices (i.e. faces-voices, faces-bodies, bodies-voices) for perceived attractiveness, physical dominance, and health. Analyses were performed using R (R Core Team, 2015). To analyse partial mediation by hormonal levels, partial correlations between two rating variables were run controlling for one hormonal variable at a time. These partial correlations were compared to bivariate correlations between the two rating variables using 95 % confidence intervals. To investigate the robustness of our findings, we ran partial correlations and regression models including the preregistered control variables targets' age (e.g. Schaefer et al., 2006; Zebrowitz & Franklin, 2014) and relationship status (binary: single vs. open relationship/committed relationship/engaged/married) as well as exploratively BMI (which is inversely associated with bodily attractiveness and weakly with facial attractiveness, e.g. Thornhill & Grammer, 1999). In exploratory analyses, the strength of correlated perceptions amongst the three attributes were compared for the different pairs of stimuli using Fisher's Z transformation. Results of additional analyses mentioned in the preregistration can be found in Kordsmeyer et al. (2024).

5. Results

5.1. Descriptive statistics including inter-rater reliabilities

Descriptive statistics including inter-rater reliabilities are depicted in Table 3. The two salivary baseline testosterone measures were strongly positively correlated in both male ($r = 0.47$, $p < .001$) and female targets ($r = 0.55$, $p < .001$), as were male targets' post-competition testosterone measures ($r = 0.79$, $p < .001$).

Table 3
Descriptive statistics and inter-rater reliabilities.

Stimuli and attributes	Male targets			Female targets		
	M	*SD*	*A*	*M*	*SD*	*α*
Facial						
Attractiveness	−0.61	1.39	0.89	−0.15	0.99	0.95
Health	0.51	1.39	0.84	0.68	1.42	0.81
Physical dominance	0.40	1.43	0.88	0.32	1.17	0.71
Bodily						
Attractiveness	−0.18	1.83	0.93	−0.04	1.01	0.98
Health	0.52	1.83	0.91	1.50	1.56	0.93
Physical dominance	0.37	1.67	0.87	0.83	1.06	0.70
Vocal						
Attractiveness	0.23	1.36	0.91	0.57	1.22	0.80
Health	0.85	1.36	0.71	0.78	1.70	0.84
Physical dominance	0.24	1.35	0.92	0.20	1.76	0.86
Baseline testosterone	81.23	25.63	–	7.68	3.20	–
1st post-comp. Testosterone	84.61	31.36	–	–	–	–
2nd post-comp. Testosterone	89.98	33.18	–	–	–	–
Hair baseline testosterone	–	–	–	0.43	0.22	0.78
Baseline estradiol	–	–	–	5.75	2.34	0.63

Note. To ease interpretation and comparison with other studies, hormonal levels are reported untransformed and after winsorisation (testosterone and estradiol levels in pg/ml), for salivary baseline testosterone, women's hair testosterone and salivary estradiol the mean of the two baseline measures is shown.

5.2. Bivariate correlations of perceptions

For the whole sample, there were significant positive correlations between facial and bodily attractiveness, health, and physical dominance (Table 4, Figs. 2 and 3, all ps < 0.001, medium effect size for attractiveness and health, small effect for physical dominance according to conventional standards, Cohen, 1988; for an overview of effects see Fig. 4). Further, facial and vocal attractiveness ($p < .001$), facial and vocal physical dominance ($p = .015$), and bodily and vocal physical dominance ($p < .001$, small effect) were significantly correlated (all small effects). Thus, bodies of targets with healthier, more attractive, and more physically dominant faces were, on average, perceived as healthier, more attractive, and more physically dominant, respectively (see also Figs. 2 and 3). Similarly, the faces of targets with more attractive and physically dominant voices were on average perceived as more attractive and physically dominant, respectively, whereas the bodies of targets with more physically dominant voices were seen as more physically dominant, on average (Fig. 4). However, the significant positive correlations between facial and vocal attractiveness, facial and bodily dominance, and facial and vocal dominance were significant for men only ($p < .001$, $p < .001$, and $p < .01$, respectively, Table 5), but not women ($p = .06$, $p = .47$, and $p = .38$, respectively). Additionally, a significant positive correlation emerged between vocal and bodily attractiveness for women only ($p = .03$, Table 5), but not men ($p = .61$). All correlations were virtually unchanged as partial correlations controlling for targets' age and relationship status as well as separately BMI (except for the association between bodily and vocal physical dominance turning non-significant for the full sample controlling for BMI, $r = 0.09$, $p = .13$, and for women only controlling for age and relationship status, $r = 0.15$, $p = .06$, and for women between vocal and bodily attractiveness controlling for BMI, $r = 0.08$, $p = .35$; for men, the correlation between bodily health and the second testosterone reactivity measure turned significant, $r = 0.16$, $p = .04$, Tables S1–S4). Intra-stimuli bivariate correlations (for faces, bodies, and voices separately) ranged 0.41–0.88 (between attractiveness and health, see Table S5), −0.05–0.41 (between attractiveness and physical dominance), and 0.04–0.45 (between health and physical dominance).

Table 4
Bivariate correlations between modalities for all attributes for the whole sample.

	Attractiveness		Health		Physical dominance	
Pearson's *r*	Bodily	Vocal	Bodily	Vocal	Bodily	Vocal
Facial …	0.44*** [0.35,0.53]	0.23*** [0.13,0.34]	0.35*** [0.25,0.45]	0.08 [−0.03,0.19]	0.29*** [0.19,0.39]	0.14* [0.03,0.24]
Bodily …	–	0.09 [−0.03,0.20]	–	0.06 [−0.06,0.17]	–	0.19*** [0.08,0.30]

Note. The rows "Facial …"/"Bodily …" depict correlations for attribute depending on attribute intersecting in columns; ***$p < .001$, **$p < .01$, *$p < .05$; 95 % confidence intervals are depicted in brackets.

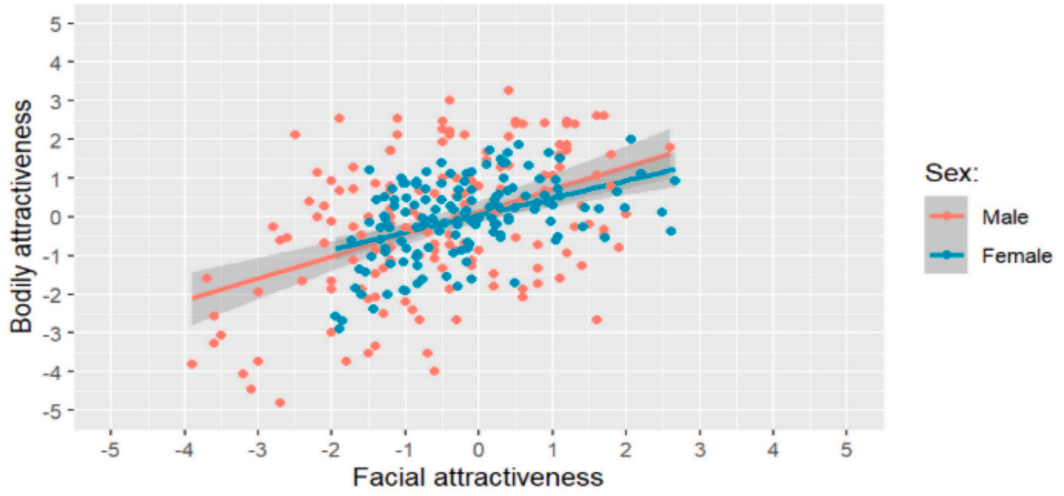

Fig. 2. Bivariate correlations between facial and bodily attractiveness, separately for target men (red), and target women (green). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 3. Bivariate correlations between facial and bodily dominance, separately for target men (red), and target women (green). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

5.3. Bivariate and partial correlations with hormonal variables

Bivariate associations of perceived attractiveness, health, and dominance of faces, bodies, and voices with hormonal variables (men's and women's baseline testosterone, testosterone reactivity, women's salivary estradiol and hair testosterone, all small effects) were mostly non-significant, except for significant positive associations of men's baseline testosterone with facial dominance, vocal attractiveness and dominance (Table 5). Partial correlations between ratings for faces, bodies, and voices controlling for hormonal variables did not differ significantly from bivariate correlations for either men or women (Table S6). Partial correlations were virtually unchanged controlling for targets' age and relationship status as well as separately BMI.

5.4. Exploratory analyses

The correlation between facial and bodily attractiveness was significantly larger than the correlations of vocal with facial or bodily attractiveness ($z = 2.91$, $p = .004$ and $z = 4.58$, $p < .001$, respectively; no significant difference between the correlations of vocal with facial or bodily attractiveness, $z = 1.75$, $p = .080$). The correlation between facial and bodily health was significantly larger than the correlations of vocal

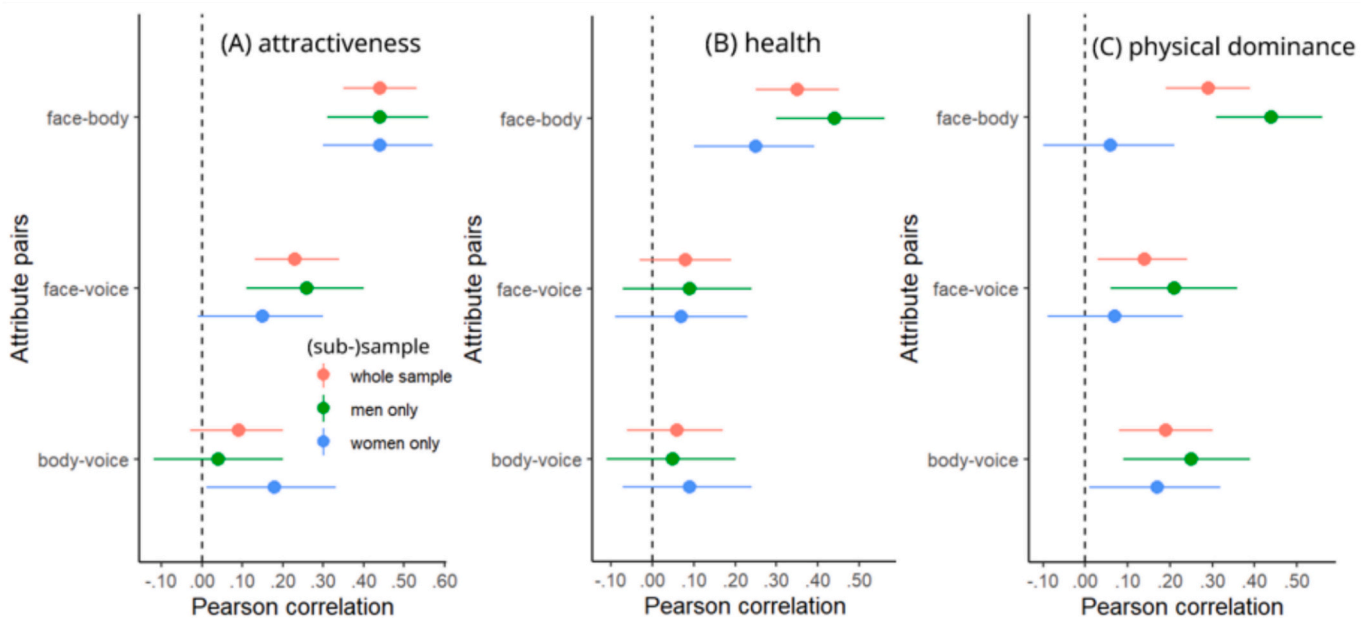

Fig. 4. Overview of bivariate correlations between stimuli by attributes, for the whole sample (red), target men only (green), and target women only (blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

with facial or bodily health ($z = 3.56$, $p < .001$ and $z = 3.81$, $p < .001$, respectively; no significant difference between the correlations of vocal with facial or bodily health, $z = 0.25$, $p = .803$). For physical dominance, there were no significant differences between correlations (all $zs < 1.96$, $ps = 0.051$).

6. Discussion

In two large samples of target men and women, we investigated cross-modal concordances of perceptions of facial, bodily, and vocal attractiveness, health, and physical dominance, as well as possible partial mediation by targets' sex steroid hormonal levels. We found significant positive associations between bodies and faces for all three attributes (for dominance only for men, not women). Associations between faces and voices for attractiveness and dominance, and between bodies and voices for dominance, were exclusive for men, while associations between bodily and vocal attractiveness were only found for women, but not men (Fig. 4). These results are mostly in line with earlier empirical findings (Fink et al., 2010; Pereira et al., 2019; Saxton et al., 2006; Smith et al., 2016) and more supportive of the one ornament hypothesis (Feinberg, 2008; Fink et al., 2010; Grammer et al., 2001; Smith et al., 2016; Thornhill & Grammer, 1999; Williams & Apicella, 2023) for faces and bodies, though we need to keep in mind the small to medium-sized effects. Faces and bodies therefore appear to convey to some extent related information about their phenotypic and perhaps genetic quality, as indicated by correlated perceptions of attractiveness, health, and physical dominance. Thus, faces and bodies of both men and women appear to some degree to function as a single ornament honestly signalling mate quality (Fink et al., 2010; Smith et al., 2016). This is in line with shared developmental pathways for bodily and facial characteristics, such as hormonal and genetic mechanisms, manifested in related degrees of fluctuating asymmetry, averageness, and sexual dimorphism for bodies and faces (e.g. Ekrami et al., 2021; Hughes et al., 2002; Peters et al., 2007). For voices, however, associations were small or even non-significant, providing evidence for the multiple messages hypothesis (Moller & Pomiankowski, 1993).

The largest associations emerged for men's and women's facial and bodily attractiveness as well as men's, but not women's, perceived facial and bodily dominance and health. These correlations between perceptions of faces and bodies are especially noteworthy, given that the bodily stimuli were headless and did not contain any cues on skin quality (see Fig. 1). For facial and bodily attractiveness, the correlation was only slightly smaller than in an earlier study in which women's face ratings were correlated with body ratings based on photographs that included their heads and wearing street clothes or swimsuits (Bleske-Rechek et al., 2014). One cue provided by both faces and bodies which may explain such associations is body weight or body fat (approximated by BMI, for instance; Little, 2014). Both men's and women's adiposity negatively predicted their facial attractiveness (Faries & Bartholomew, 2012; Foo et al., 2017; Xia et al., 2025) and bodily attractiveness (Brierley et al., 2016; Thornhill & Grammer, 1999). However, in our study, correlations between facial and bodily attractiveness were robust to and only slightly smaller when controlling for BMI (see Table S3), leaving a large share of variance unexplained. Another cue of facial attractiveness which may also be relevant to bodies is youthful appearance (Little, 2014). Youthfulness may as well be a cue that explains the relatively large correlation for perceived health in our study (though surprisingly in men only). Future research should investigate perceived youthfulness for faces and bodies as a potential moderator. However, it should be noted that at least for the bodily stimuli in our study, youth was hardly detectable due to unavailable skin information. A further candidate cue is averageness, which is particularly relevant for faces, defined as resemblance to other faces within a population (Komori et al., 2009; Lee et al., 2016; Lee et al., 2025; Leger et al., 2024; Little, 2014). Averageness has been associated with perceived facial health und attractiveness (Foo et al., 2017; Leger et al., 2024). On the contrary, for bodies, averageness may not be related to perceptions of attractiveness or health in a simple linear fashion. For example, women's thinness and fat mass and men's height and waist-chest ratio have been shown to be associated with perceived attractiveness or health in non-linear ways (Brierley et al., 2016; Brown & Slaughter, 2011; Fan et al., 2005; Stulp et al., 2013; Weeden & Sabini, 2005). Further proposed cues to health and attractiveness relevant to both faces and bodies are symmetry (Fink et al., 2006; Tovée et al., 2000) and sexual dimorphism (masculinity in men, femininity in women, Little, 2014; sexual dimorphism may be more relevant in women than men, Lee et al., 2025). While recent findings on symmetry were mostly inconsistent for perceptions of attractiveness and health (e.g. Lee et al., 2025; Leger et al., 2024), sexual

Table 5
Bivariate correlations between main variables separately for male and female targets.

	Attractiveness			Health			Physical dominance		
Pearson's *r*	Facial	Bodily	Vocal	Facial	Bodily	Vocal	Facial	Bodily	Vocal
Facial …	–	0.44*** [0.31,0.56]/0	0.26*** [0.11,0.40]/0	–	0.44*** [0.30,0.56]/0	0.09 [−0.07,0.24]/0.07 [−0.09,0.23]	–	0.44*** [0.31,0.56]/0	0.21** [0.06,0.36]/0
		.44*** [0.30,0.57]	.15 [−0.01,0.30]		.25** [0.10,0.39]			.06 [−0.10,0.21]	.07 [−0.09,0.23]
Bodily …	–	–	0.04 [−0.12,0.20]/0.18* [0.01,0.33]	–	–	0.05 [−0.11,0.20]/0.09 [−0.07,0.24]	–	–	0.25** [0.09,0.39]/0.17* [0.01,0.32]
Baseline T	0.07 [−0.09,0.22]/-0.12 [−0.27,0.04]	−0.01 [−0.17,0.14]/-0.14 [−0.30,0.02]	0.19* [0.03,0.33]/0.06 [−0.10,0.22]	0.02 [−0.13,0.17]/0.05 [−0.11,0.21]	0.06 [−0.10,0.21]/-0.12 [−0.28,0.03]	0.02 [−0.13,0.18]/0.10 [−0.06,0.25]	0.15 [0.00,0.30]/0.14 [−0.01,0.30]	−0.02 [−0.18,0.14]/-0.05 [−0.20,0.11]	0.19* [0.04,0.34]/0.03 [−0.12,0.19]
1st T reactivity	0.06 [−0.09,0.22]/.	0.07 [−0.09,0.22]/.	−0.07 [−0.23,0.08]/.	−0.11 [−0.26,0.05]/.	0.08 [−0.07,0.23]/.	−0.12 [−0.27,0.04]/.	−0.06 [−0.21,0.09]/.	0.08 [−0.08,0.24]/.	−0.06 [−0.22,0.09]/.
2nd T reactivity	0.09 [−0.07,0.24]/.	0.05 [−0.11,0.21]/.	−0.01 [−0.17,0.14]/.	−0.04 [−0.19,0.12]/.	0.10 [−0.06,0.25]/.	−0.01 [−0.16,0.15]/.	0.08 [−0.08,0.23]/.	0.08 [−0.08,0.24]/.	−0.02 [−0.18,0.13]/.
Hair T	./−0.04 [−0.22,0.13]	./−0.11 [−0.29,0.07]	./0.01 [−0.17,0.18]	./−0.01 [−0.19,0.16]	./−0.13 [−0.30,0.05]	./−0.02 [−0.19,0.15]	./0.06 [−0.12,0.23]	./−0.11 [−0.28,0.06]	./−0.07 [−0.24,0.11]
E	./−0.04 [−0.20,0.12]	./−0.02 [−0.18,0.15]	./−0.01 [−0.17,0.15]	./0.00 [−0.16,0.16]	./0.01 [−0.15,0.17]	./0.07 [−0.09,0.22]	./−0.03 [−0.19,0.12]	./0.03 [−0.13,0.19]	./0.09 [−0.07,0.24]
T/E ratio	./−0.04 [−0.20,0.12]	./−0.10 [−0.26,0.07]	./0.05 [−0.11,0.20]	./0.08 [−0.08,0.24]	./−0.11 [−0.26,0.05]	./0.01 [−0.15,0.17]	./0.11 [−0.04,0.27]	./−0.04 [−0.20,0.12]	./−0.03 [−0.18,0.13]

Note. Correlations for target men/women are shown before/after brackets; the rows "Facial …"/"Bodily …" depict correlations for attribute depending on attribute intersecting in columns; "T" = testosterone (baseline for men and women, reactivity only for men available), "E" = Estradiol; ***$p < .001$, **$p < .01$, *$p < .05$; 95 % confidence intervals are depicted in brackets.

dimorphism may partly explain cross-modally correlated perceptions of health and attractiveness (for which genetic and molecular mechanisms have been proposed, e.g. Williams & Carroll, 2009). Moreover, sexual dimorphism could specifically explain the relatively strong correlation for dominance in men. Hence, follow-up studies should examine whether such cross-modal perceptions are explained better if measures of femininity (instead of only dominance perceptions) are also included for both women's faces and bodies.

Regarding the underlying mechanisms of correlated perceptions of facial and bodily attractiveness, it has been suggested that facial and bodily characteristics may share some underlying factor of genetic quality (e.g. due to deleterious mutation load, inbreeding depression, or incompatible genes) that translate to perceptions of attractiveness (Thornhill & Grammer, 1999). For facial attractiveness and facial averageness a strong genetic component has been demonstrated, while the genetic correlation between these two measures may be smaller than assumed initially (Lee et al., 2016). Besides genetic factors, remaining variance in facial attractiveness may be explained by environmental perturbations during development (and measurement error, Lee et al., 2016). Environmental perturbations, for example due to pathogen infections, toxins, or malnutrition, may manifest in both facial and bodily asymmetry, which may contribute to correlated perceptions of facial and bodily attractiveness. However, as alluded to above, associations of facial and bodily symmetry with attractiveness are inconsistent and small at best (e.g. Lee et al., 2025; Leger et al., 2024). Theoretically, developmental instability, for which (a-)symmetry is only a weak indicator (Graham & Özener, 2016), could still explain correlations between facial and bodily attractiveness, influenced by both genetic quality and environmental perturbations. Besides symmetry, a more likely cue is sexual dimorphism, manifested as masculinity in men and femininity in women, with associated genetic and molecular mechanisms (e.g. Lee et al., 2014; Williams & Carroll, 2009). However, associations of physical dominance as a proxy measure of masculinity with attractiveness in men are relatively weak as well (e.g. Kordsmeyer et al., 2024), calling for further research specifically examining both objective measures and perceptions of masculinity in men and femininity in women alongside genetic factors (e.g. including paternal age at conception as a proxy of mutation load, Lee et al., 2016; testing candidate genes via GWAS studies, for an overview see White & Puts, 2019; in twin studies, Lee et al., 2014).

All of the significant correlations were robust to controlling for target BMI or age and relationship status. Previous research has shown negative associations of BMI with bodily attractiveness and inconsistently with facial and vocal attractiveness (e.g. Collins & Missing, 2003; Hughes et al., 2004; Thornhill & Grammer, 1999), and BMI has been proposed as potential confounder of correlated cross-modal perceptions for both attractiveness and health (e.g. Coetzee et al., 2009; Weeden & Sabini, 2005), for which we found no support here.

Cross-modal perceptions of dominance were significantly correlated for men only, which is in line with suggestions that intrasexual selection for dominance-related characteristics was more prominent in men than in women (Puts, 2010), whereas attractiveness and health are relevant attributes regarding the mate quality of both sexes. On the other hand, voices seem to form a more separate modality, conveying separate information about individuals' health (in line with some earlier null associations, e.g. Oguchi & Kikuchi, 1997; Wells et al., 2013; contrary to earlier significant positive associations, e.g. Rezlescu et al., 2015; Saxton et al., 2006; Williams & Apicella, 2023), and partially redundant information regarding individuals' attractiveness and dominance relative to signalling by faces and bodies. Such small, non-significant associations are more in line with the multiple messages hypothesis than with the one ornament hypothesis (Moller & Pomiankowski, 1993; Třebický et al., 2023; Williams & Apicella, 2023).

Vocal and facial characteristics like voice pitch and facial masculinity have been discussed in the literature as evolved dominance signals, which should be associated with physical strength ontogenetically

driven by testosterone (e.g. Fink et al., 2007; Wolff & Puts, 2010). In our study, there was a significant positive (albeit small) association between perceived facial and vocal physical dominance for men, but not women, providing some evidence for these suggestions sensu the one ornament hypothesis. However, only men's baseline testosterone levels were related to perceived vocal dominance, with no further significant associations between perceptions of dominance and hormonal variables examined herein. For men, we found a medium-sized positive correlation between bodily and facial physical dominance (non-significant for women), in contrast to earlier suggestions of the body signalling masculinity via a large shoulder-to-hip ratio and muscularity, which are not directly detectable in the face. Other studies have shown that perceptions of facial dominance are related to bodily characteristics like shoulder width, muscle mass, and fat mass (Lei et al., 2019; Windhager et al., 2011). Hence, overall for physical dominance we provide very limited evidence for the one ornament hypothesis for women, but more for the multiple messages hypothesis, and mixed evidence for men.

For health, we demonstrate correlated perceptions of faces and bodies, but not of vocal with bodily or facial health (in contrast to one of the few available studies reporting a strong positive correlation between facial and vocal health, Smith et al., 2016). We directly assessed health perceptions, rather than extrapolating findings based on attractiveness perceptions to health (e.g. Fink et al., 2010; Třebický et al., 2023). The relatively strong correlation between facial and bodily health may seem surprising, given earlier evidence which suggested that faces and bodies should provide different cues to health (e.g. hair quality, face shape, skin texture and colour for faces, for bodies muscularity and shoulder-to-hip ratio in men and waist-to-hip ratio in men, Bovet, 2019; Henderson et al., 2016; Hinsz et al., 2001; Pazhoohi et al., 2019; Stephen & Luoto, 2023; Williams & Apicella, 2023). This is amplified by the fact that skin quality was deliberately masked in our body scan stimuli (which were consistently coloured in grey) to shift the focus to physical shape. Apparently pure body shape information can also convey cues to subjectively perceived health. A theoretical candidate mechanism would be hormone-dependent body development. Future studies should replicate our study using bodily stimuli with natural skin to investigate if associations are robust when information on skin quality is available. However, there were no moderating effects of or bivariate associations with hormonal measures for health perceptions, contrary to theoretical speculations of faces and bodies (and potentially voices) as condition-dependent ornaments signalling health affected by hormonal levels (Fink et al., 2010; Foo et al., 2017; Smith et al., 2016; Thornhill & Grammer, 1999). These findings need to be replicated and extended, most importantly by examining organising effects of prenatal and pubertal hormonal levels, which should be more relevant for the development of sexually dimorphic characteristics than current adult hormone levels (e.g. Berenbaum & Beltz, 2011; Bhasin, 2003; Marečková et al., 2011). Importantly, we need to stress that we assessed subjective impressions of health, and no objective health measures. Future studies should examine the validity of these subjective impressions using direct measures of health (e.g. Bulczak & Gugushvili, 2023; Rhodes et al., 2001).

Some positive associations between perceptions of faces and bodies were close to large effects according to conventional standards (Cohen, 1988) and large according to typical effect sizes in individual difference research (Gignac & Szodorai, 2016). In other words, facial and bodily attractiveness, and for men also health and physical dominance, were strongly associated, especially considering that they were judged by separate groups of raters (Třebický et al., 2023 showed that associations were stronger for within-rater compared to between-rater designs). Further correlations, especially for voices, were mostly medium-sized or small. While some large effects support the one ornament hypothesis, the smaller effect sizes for voices and for physical dominance perceptions for women provide partial support for the multiple messages hypothesis. It has been suggested that these two theories are not mutually exclusive, and that body parts and modalities can have both independent and redundant effects on perceptions of attractiveness and related attributes and hence mate quality (Groyecka et al., 2017; Williams & Apicella, 2023). Our study underlines that especially faces and bodies signal partly redundant information about phenotypic and potentially genotypic quality, whereas voices are a more independent modality. Still, some ambiguity prevails regarding which effect sizes are required to provide clearer evidence for either the one ornament hypothesis or the multiple messages hypothesis. A (perhaps too) strong interpretation of the one ornament hypothesis itself suggests cross-modal correlations close to unity may be necessary, which however cannot be expected given imperfect interrater agreement (especially for between-rater designs, Třebický et al., 2023) and hence imperfect reliability. The medium-sized effects in our study show that at least faces and bodies are partially, but not completely, redundant signals of mate-relevant qualities, while still considerable amounts of variance are unexplained (e.g. 80.6 % for attractiveness based on $r = 0.44$). Thus, future theoretical work would benefit empirical tests most by specifying effect size ranges which would differentiate between the one ornament hypothesis and the multiple messages hypothesis. Moreover, future studies should incorporate further modalities, such as body odours (Lobmaier et al., 2018; Schirmer et al., 2025; Třebický et al., 2023) or body motion (Fink et al., 2015; Schirmer et al., 2025), for a more complete understanding of multi-modal signalling of attributes relevant to intrasexual and intersexual selection.

6.1. Hormonal mechanisms

Ontogenetic mechanisms of developmental stability have been hypothesised to manifest in sexually dimorphic anatomical features such as muscularity, thus driving correlated perceptions of particularly attractiveness and dominance (Kordsmeyer et al., 2024). Hormonal variables have been put forth as modulators of sexually dimorphic development of facial, bodily, and vocal characteristics, and hence drivers of correlated perceptions (Fink et al., 2010; Gangestad & Scheyd, 2005; Stephen & Luoto, 2023; Thornhill & Grammer, 1999; Williams & Apicella, 2023). However, in our study, no partial mediation by any of the hormonal variables (salivary baseline testosterone, testosterone reactivity, hair testosterone, salivary baseline estradiol, testosterone/estradiol ratio) aligning with our hypotheses was found. All partial correlations controlling for hormonal variables did not differ significantly from bivariate correlations between faces, voices, or bodies for rating of attractiveness, health, or physical dominance. Thus, at least for the stimuli, attributes, and the hormonal variables examined here, we do not provide evidence for correlated perceptions being driven by adult hormonal levels (contrary to earlier suggestions, e.g. Gangestad & Scheyd, 2005; Thornhill & Grammer, 1999; Williams & Apicella, 2023). The one body part for which sex hormones may still play a role as an explanatory mechanism are men's faces, based on significant correlations of baseline testosterone with facial attractiveness, health, and physical dominance, which should be examined further. For a more comprehensive investigation, future studies should examine men's hair testosterone levels and women's testosterone reactivity, which were not available in our data. Most importantly, future research should incorporate measures of organisational hormonal effects during prenatal development and puberty, which can be expected to have effects on facial, bodily, and vocal characteristics, on contrast to the hormonal associations investigated in our study.

6.2. Sex differences

It has been suggested that some cross-modal associations may differ by target sex (Groyecka et al., 2017; Williams & Apicella, 2023). In our study, some correlations were stronger descriptively for male than female targets (between facial and vocal attractiveness, facial and bodily health, facial and bodily dominance, facial and vocal dominance; only the correlation between bodily and vocal attractiveness was stronger in

women, though most confidence intervals were overlapping, Table 5). These sex differences are mostly in contrast to earlier findings, since in many studies associations between facial and vocal attractiveness, for instance, were larger in women (e.g. Williams & Apicella, 2023). At least in our study, results for target men are more in line with the one ornament hypothesis, and somewhat more in line with the multiple messages hypothesis for women. This is further corroborated by bivariate associations of perceptions of faces with one hormonal variable (baseline testosterone levels) in men, but not women. Further research is warranted to replicate and elucidate our results.

6.3. Limitations and recommendations for future research

Our results suggest that human faces, bodies, and voices display multiple, partly redundant cues to the same underlying quality. However, a few shortcomings limit the generalisability of our findings. Regarding hormonal moderators, the analysis methods for our hormonal samples were not consistent due to different study designs: immunoassays for men's salivary testosterone and women's salivary estradiol, liquid chromatography–mass spectrometry (LC-MS/MS) for women's salivary and hair testosterone. It should be noted that there are currently no valid LC-MS/MS protocols for detecting estradiol levels (see Jünger et al., 2018). Relatedly, the validity of our estradiol measures may be limited (e.g. see Arslan et al., 2023 and Brouillard et al., 2025 for critical evidence on limited validity of salivary estradiol; but see Stern et al., 2022 for evidence of good validity of women's salivary testosterone measured with LC-MS/MS). Hence, low validity may at least partly explain our null findings regarding hormonal moderators. Future studies should replicate our results employing LC-MS/MS-based hormone assessment, for which superior validity has been demonstrated compared to immunoassays (e.g. Brouillard et al., 2025).

Further, perceptions of faces were based on two-dimensional static stimuli only, while three-dimensional and dynamic stimuli may provide more valid information (e.g. Hönekopp et al., 2007; Kordsmeyer et al., 2020; though this may differ by the attribute judged, Smith et al., 2016). The external validity of our body scan stimuli was limited, given that information on skin quality/texture was missing, and stimuli were static (albeit turning around their vertical axis for a 360° view), providing no information on movement (e.g. Fink et al., 2015; Hönekopp et al., 2007). For judgments of voice, we had to use different vocal stimuli for men and women from existing data (an unstandardised excerpt from short free speech was used for men, and one standardised sentence from the rainbow passage for women), though comparable in length and recording condition (i.e. without social context). However, both were naturalistic speech stimuli, which have been suggested to allow for more valid judgments compared to, for instance, isolated vowels (Zäske et al., 2020). Still, in follow-up studies correlated perceptions should be compared using the same kind of vocal stimuli for men and women. Future studies could also employ a cross-cultural perspective, comparing correlated perceptions in individualistic versus collectivistic cultures (Kordsmeyer et al., 2024) or differentiating between countries' socio-economic development, for which differing attractiveness perceptions have been shown (Swami & Tovée, 2005). For instance, vocal attractiveness ratings could be influenced by socio-cultural preferences, rather than only direct preferences for vocal characteristics (Williams & Apicella, 2023). One study found somewhat differing associations between facial and vocal attractiveness in Czech versus Brazilian targets (Valentova et al., 2017).

Finally, the existence of cross-modal ornaments suggests that individuals may have been selected to produce characteristics that consistently signal qualities (Feinberg et al., 2008a; Fink et al., 2010). To better understand such signalling, studies could examine further characteristics associated with these correlated perceptions, such as facial and bodily fluctuating asymmetry as an indicator of developmental instability and hence potentially genetic quality, or body shape (e.g. waist-to-hip ratio in women, shoulder-to-hip ratio in men) conveying reproductive value (Bovet, 2019; Finkel & Baumeister, 2009; Jasieńska et al., 2004; Van Dongen & Gangestad, 2011; Watkins, 2025; Williams & Apicella, 2023). Moreover, future research could investigate if indeed individuals with more consistent facial and bodily (and to some extent vocal) signals have a reproductive advantage, for example assessed by mating success or ideally reproductive success over more than one generation, while comparing perceptions of different attributes and associations for male versus female targets (e.g. Feinberg et al., 2008a; Fink et al., 2010; Thornhill & Grammer, 1999). This could shed light on previous and contemporary selection pressures.

7. Conclusion

In this study, the bodies of men and women with healthier, more attractive, and more physically dominant faces were perceived as healthier, more attractive, and more physically dominant, while cross-modal associations were weaker for judgments of voices. Keeping in mind the mostly medium-sized effects, our results somewhat support the one ornament hypothesis for faces and bodies, and mostly the multiple messages hypothesis for voices. Our results imply that faces and bodies signal fitness-relevant mate qualities in a similar way, while voices convey cues somewhat different from faces and bodies. However, previously suggested hormonal dependency of these correlated perceptions was not supported in our study, leaving room for further investigation into other hormonal or non-hormonal mechanisms.

CRediT authorship contribution statement

Tobias L. Kordsmeyer: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Philine A.C. Rasokat:** Writing – original draft, Conceptualization. **Julia Stern:** Writing – review & editing, Investigation. **Christoph Schild:** Writing – review & editing, Investigation. **Lars Penke:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

None.

Appendix A. Supplementary data

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References

Abend, P., Pflüger, L. S., Koppensteiner, M., Coquerelle, M., & Grammer, K. (2015). The sound of female shape: A redundant signal of vocal and facial attractiveness. *Evolution and Human Behavior, 36*, 174–181. https://doi.org/10.1016/j.evolhumbehav.2014.10.004

Arslan, R. C., Blake, K., Botzet, L. J., Bürkner, P. C., DeBruine, L., Fiers, T., … Stern, J. (2023). Not within spitting distance: Salivary immunoassays of estradiol have subpar validity for predicting cycle phase. *Psychoneuroendocrinology, 149*, Article 105994. https://doi.org/10.1016/j.psyneuen.2022.105994

Berenbaum, S. A., & Beltz, A. M. (2011). Sexual differentiation of human behavior: Effects of prenatal and pubertal organizational hormones. *Frontiers in Neuroendocrinology, 32*, 183–200. https://doi.org/10.1016/j.yfrne.2011.03.001

Bhasin, S. (2003). Regulation of body composition by androgens. *Journal of Endocrinological Investigation, 26*, 814–822. https://doi.org/10.1007/BF03345230

Bleske-Rechek, A., Kolb, C. M., Stern, A. S., Quigley, K., & Nelson, L. A. (2014). Face and body: Independent predictors of women's attractiveness. *Archives of Sexual Behavior, 43*, 1355–1365. https://doi.org/10.1007/s10508-014-0304-4

Bovet, J. (2019). Evolutionary theories and men's preferences for women's waist-to-hip ratio: Which hypotheses remain? A systematic review. *Frontiers in Psychology, 10*, 1221. https://doi.org/10.3389/fpsyg.2019.01221

Brierley, M. E., Brooks, K. R., Mond, J., Stevenson, R. J., & Stephen, I. D. (2016). The body and the beautiful: Health, attractiveness and body composition in men's and women's bodies. *PLoS One, 11*, Article e0156722. https://doi.org/10.1371/journal.pone.0156722

Brouillard, A., Davignon, L. M., Cernik, R., Giguère, C.É., Findlay, H., Juster, R. P., … Marin, M. F. (2025). Comparing immunoassay and mass spectrometry techniques for

salivary sex hormone analysis. *Psychoneuroendocrinology*. https://doi.org/10.1016/j.psyneuen.2025.107379, 107379.
Brown, F. L., & Slaughter, V. (2011). Normal body, beautiful body: Discrepant perceptions reveal a pervasive 'thin ideal' from childhood to adulthood. *Body Image, 8*, 119–125. https://doi.org/10.1016/j.bodyim.2011.02.002
Bulczak, G., & Gugushvili, A. (2023). Physical attractiveness and cardiometabolic risk. *American Journal of Human Biology, 35*, Article e23895. https://doi.org/10.1002/ajhb.23895
Burt, K. B., & Obradovic, J. (2013). The construct of psychophysiological reactivity: Statistical and psychometric issues. *Developmental Review, 33*, 29–57. https://doi.org/10.1016/j.dr.2012.10.002
Cartei, V., Bond, R., & Reby, D. (2014). What makes a voice masculine: Physiological and acoustical correlates of women's ratings of men's vocal masculinity. *Hormones and Behavior, 66*, 569–576. https://doi.org/10.1016/j.yhbeh.2014.08.006
Cheng, J. T., Kornienko, O., & Granger, D. A. (2018). Prestige in a large-scale social group predicts longitudinal changes in testosterone. *Journal of Personality and Social Psychology, 114*, 924. https://doi.org/10.1037/pspi0000126
Coetzee, V., Perrett, D. I., & Stephen, I. D. (2009). Facial adiposity: A cue to health? *Perception, 38*, 1700–1711. https://doi.org/10.1068/p6423
Cohen, J. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.
Collins, S. A., & Missing, C. (2003). Vocal and visual attractiveness are related in women. *Animal Behaviour, 65*(5), 997–1004. https://doi.org/10.1006/anbe.2003.2123
De Jager, S., Coetzee, N., & Coetzee, V. (2018). Facial adiposity, attractiveness, and health: A review. *Frontiers in Psychology, 9*, 2562. https://doi.org/10.3389/fpsyg.2018.02562
Edwards, D. A., & Casto, K. V. (2013). Women's intercollegiate athletic competition: Cortisol, testosterone, and the dual-hormone hypothesis as it relates to status among teammates. *Hormones and Behavior, 64*, 153–160. https://doi.org/10.1016/j.yhbeh.2013.03.003
Ekrami, O., Claes, P., Van Assche, E., Shriver, M. D., Weinberg, S. M., Marazita, M. L., … Van Dongen, S. (2021). Fluctuating asymmetry and sexual dimorphism in human facial morphology: A multi-variate study. *Symmetry, 13*, 304. https://doi.org/10.3390/sym13020304
Fairbanks, G. (1960). *Voice and articulation drillbook*. Harper & Row.
Fan, J., Dai, W., Liu, F., & Wu, J. (2005). Visual perception of male body attractiveness. *Proceedings of the Royal Society B: Biological Sciences, 272*, 219–226. https://doi.org/10.1098/rspb.2004.2922
Faries, M. D., & Bartholomew, J. B. (2012). The role of body fat in female attractiveness. *Evolution and Human Behavior, 33*, 672–681. https://doi.org/10.1016/j.evolhumbehav.2012.05.002
Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149–1160. https://doi.org/10.3758/BRM. 41.4.1149
Feinberg, D. R. (2008). Are human faces and voices ornaments signaling common underlying cues to mate value? *Evolutionary Anthropology, 17*(2), 112–118. https://doi.org/10.1002/evan.20166
Feinberg, D. R., DeBruine, L. M., Jones, B. C., & Little, A. C. (2008). Correlated preferences for men's facial and vocal masculinity. *Evolution and Human Behavior, 29*, 233–241. https://doi.org/10.1016/j.evolhumbehav.2007.12.008
Feinberg, D. R., Jones, B. C., DeBruine, L. M., Law Smith, M. J., Cornwell, R. E., & Perrett, D. I. (2006). Maintenance of vocal sexual dimorphism: Adaptive selection against androgyny. In *18th Human Behavior and Evolution Society (HBES) Conference, Philadelphia*.
Feinberg, D. R., Jones, B. C., DeBruine, L. M., Moore, F. R., Law Smith, M. J., Cornwell, R. E., … Perrett, D. I. (2005). The voice and face of woman: One ornament that signals quality? *Evolution and Human Behavior, 26*, 398–408. https://doi.org/10.1016/j.evolhumbehav.2005.04.001
Fink, B., Neave, N., Manning, J. T., & Grammer, K. (2006). Facial symmetry and judgements of attractiveness, health and personality. *Personality and Individual Differences, 41*, 491–499. https://doi.org/10.1016/j.paid.2006.01.017
Fink, B., Neave, N., & Seydel, H. (2007). Male facial appearance signals physical strength to women. *American Journal of Human Biology, 19*, 82–87. https://doi.org/10.1002/ajhb.20583
Fink, B., Täschner, K., Neave, N., Hugill, N., & Dane, L. (2010). Male faces and bodies: Evidence of a condition-dependent ornament of quality. *Personality and Individual Differences, 49*(5), 436–440. https://doi.org/10.1016/j.paid.2010.04.013
Fink, B., Weege, B., Neave, N., Pham, M. N., & Shackelford, T. K. (2015). Integrating body movement into attractiveness research. *Frontiers in Psychology, 6*, 220. https://doi.org/10.3389/fpsyg.2015.00220
Finkel, E. J., & Baumeister, R. F. (2009). Attraction and rejection. In R. F. Baumeister, & E. J. Finkel (Eds.), *Advanced social psychology* (pp. 419–459). New York: Oxford University Press.
Foo, Y. Z., Simmons, L. W., & Rhodes, G. (2017). Predictors of facial attractiveness and health in humans. *Scientific Reports, 7*, Article 39731. https://doi.org/10.1038/srep39731
Gangestad, S. W., & Scheyd, G. J. (2005). The evolution of human physical attractiveness. *Annual Review of Anthropology, 34*, 523–548. https://doi.org/10.1146/annurev.anthro.33.070203.143733
Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences, 102*, 74–78. https://doi.org/10.1016/j.paid.2016.06.069
Graham, J. H., & Özener, B. (2016). Fluctuating asymmetry of human populations: A review. *Symmetry, 8*(12), 154. https://doi.org/10.3390/sym8120154
Grammer, K., Fink, B., Juette, A., Ronzal, G., & Thornhill, R. (2001). Female faces and bodies: N-dimensional feature space and attractiveness. In G. Rhodes, & L. Zebrowitz (Eds.), *Advances in visual cognition* (pp. 91–125). Ablex Publishing.
Grammer, K., & Thornhill, R. (1994). Human (*Homo sapiens*) facial attractiveness and sexual selection: The role of symmetry and averageness. *Journal of Comparative Psychology, 108*(3), 233–242. https://doi.org/10.1037/0735-7036.108.3.233
Groyecka, A., Pisanski, K., Sorokowska, A., Havlíček, J., Karwowski, M., Puts, D., … Sorokowski, P. (2017). Attractiveness is multimodal: Beauty is also in the nose and ear of the beholder. *Frontiers in Psychology, 8*, 778. https://doi.org/10.3389/fpsyg.2017.00778
Grymowicz, M., Rudnicka, E., Podfigurna, A., Napierala, P., Smolarczyk, R., Smolarczyk, K., & Meczekalski, B. (2020). Hormonal effects on hair follicles. *International Journal of Molecular Sciences, 21*, 5342. https://doi.org/10.3390/ijms21155342
Henderson, A. J., Holzleitner, I. J., Talamas, S. N., & Perrett, D. I. (2016). Perception of health from facial cues. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 371*, Article 20150380. https://doi.org/10.1098/rstb.2015.0380
Hinsz, V. B., Matz, D. C., & Patience, R. A. (2001). Does women's hair signal reproductive potential? *Journal of Experimental Social Psychology, 37*, 166–172. https://doi.org/10.1006/jesp.2000.1450
Hönekopp, J., Rudolph, U., Beier, L., Liebert, A., & Müller, C. (2007). Physical attractiveness of face and body as indicators of physical fitness in men. *Evolution and Human Behavior, 28*, 106–111. https://doi.org/10.1016/j.evolhumbehav.2006.09.001
Hughes, S. M., Dispenza, F., & Gallup, G. G., Jr. (2004). Ratings of voice attractiveness predict sexual behavior and body configuration. *Evolution and Human Behavior, 25*, 295–304. https://doi.org/10.1016/j.evolhumbehav.2004.06.001
Hughes, S. M., Harrison, M. A., & Gallup, G. G., Jr. (2002). The sound of symmetry: Voice as a marker of developmental instability. *Evolution and Human Behavior, 23*, 173–180. https://doi.org/10.1016/S1090-5138(01)00099-X
Jasieńska, G., Ziomkiewicz, A., Ellison, P. T., Lipson, S. F., & Thune, I. (2004). Large breasts and narrow waists indicate high reproductive potential in women. In , *271*. *Proceedings of the Royal Society of London. Series B: Biological Sciences* (pp. 1213–1217). https://doi.org/10.1098/rspb.2004.2712
Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., Lao, J., … DeBruine, L. M. (2018). No compelling evidence that more physically attractive young adult women have higher estradiol or progesterone. *Psychoneuroendocrinology, 98*, 1–5. https://doi.org/10.1016/j.psyneuen.2018.07.026
Jünger, J., Kordsmeyer, T. L., Gerlach, T. M., & Penke, L. (2018). Fertile women evaluate male bodies as more attractive, regardless of masculinity. *Evolution and Human Behavior, 39*, 412–423. https://doi.org/10.1016/j.evolhumbehav.2018.03.007
Klimek, M., Galbarczyk, A., Nenko, I., Alvarado, L. C., & Jasienska, G. (2014). Digit ratio (2D: 4D) as an indicator of body size, testosterone concentration and number of children in human males. *Annals of Human Biology, 41*, 518–523. https://doi.org/10.3109/03014460.2014.902993
Komori, M., Kawamura, S., & Ishihara, S. (2009). Averageness or symmetry: Which is more important for facial attractiveness? *Acta Psychologica, 131*, 136–142. https://doi.org/10.1016/j.actpsy.2009.03.008
Kordsmeyer, T. L., Freund, D., Pita, S. R., Jünger, J., & Penke, L. (2019). Further evidence that facial width-to-height ratio and global facial masculinity are not positively associated with testosterone levels. *Adaptive Human Behavior and Physiology, 5*, 117–130. https://doi.org/10.1007/s40750-018-0105-4
Kordsmeyer, T. L., Freund, D., Ueshima, A., Kuroda, K., Kameda, T., & Penke, L. (2024). Halo effect of faces and bodies: Cross-cultural similarities and differences between German and Japanese observers. *Personality Science, 5*. https://doi.org/10.1177/27000710241257814, 27000710241257814.
Kordsmeyer, T. L., Lohöfener, M., & Penke, L. (2019). Male facial attractiveness, dominance, and health and the interaction between cortisol and testosterone. *Adaptive Human Behavior and Physiology, 5*, 1–12. https://doi.org/10.1007/s40750-018-0098-z
Kordsmeyer, T. L., Stern, J., & Penke, L. (2019). 3D anthropometric assessment and perception of male body morphology in relation to physical strength. *American Journal of Human Biology, 31*, Article e23276. https://doi.org/10.1002/ajhb.23276
Kordsmeyer, T. L., Thies, Y. T., Ekrami, O., Stern, J., Schild, C., Spoiala, C., … Penke, L. (2020). No evidence for an association between facial fluctuating asymmetry and vocal attractiveness in men or women. *Evolutionary Human Sciences, 2*, Article e35. https://doi.org/10.1017/ehs.2020.36
Law Smith, M. J., Perrett, D. I., Jones, B. C., Cornwell, R. E., Moore, F. R., Feinberg, D. R., … Hillier, S. G. (2006). Facial appearance is a cue to oestrogen levels in women. *Proceedings of the Royal Society B: Biological Sciences, 273*, 135–140. https://doi.org/10.1098/rspb.2005.3296
Lee, A. J., Mitchem, D. G., Wright, M. J., Martin, N. G., Keller, M. C., & Zietsch, B. P. (2014). Genetic factors that increase male facial masculinity decrease facial attractiveness of female relatives. *Psychological Science, 25*, 476–484. https://doi.org/10.1177/0956797613510724
Lee, A. J., Mitchem, D. G., Wright, M. J., Martin, N. G., Keller, M. C., & Zietsch, B. P. (2016). Facial averageness and genetic quality: Testing heritability, genetic correlation with attractiveness, and the paternal age effect. *Evolution and Human Behavior, 37*, 61–66. https://doi.org/10.1016/j.evolhumbehav.2015.08.003
Lee, P., Li, J., Rafiee, Y., Jones, B. C., & Shiramizu, V. K. M. (2025). Further evidence that averageness and femininity, rather than symmetry and masculinity, predict facial attractiveness judgments. *Scientific Reports, 15*, 5498. https://doi.org/10.1038/s41598-025-86974-0
Leger, K., Dong, J., DeBruine, L. M., Jones, B. C., & Shiramizu, V. K. (2024). Assessing the roles of symmetry, prototypicality, and sexual dimorphism of face shape in health

perceptions. *Adaptive Human Behavior and Physiology, 10*, 18–30. https://doi.org/10.1007/s40750-024-00233-6
Lei, X., Holzleitner, I. J., & Perrett, D. I. (2019). The influence of body composition effects on male facial masculinity and attractiveness. *Frontiers in Psychology, 9*, 2658. https://doi.org/10.3389/fpsyg.2018.02658
Lephart, E. D. (2018). A review of the role of estrogen in dermal aging and facial attractiveness in women. *Journal of Cosmetic Dermatology, 17*, 282–288. https://doi.org/10.1111/jocd.12508
Lewis, D. M., Evans, K. C., & Al-Shawaf, L. (2022). The logic of physical attractiveness: What people find attractive, when, and why. In D. M. Buss (Ed.), *The Oxford handbook of human mating* (pp. 178–205). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197536438.013.22.
Lewis, J. G. (2006). Steroid analysis in saliva: An overview. *Clinical Biochemist Reviews, 27*, 139–146.
Leys, C., Delacre, M., Mora, Y. L., Lakens, D., & Ley, C. (2019). How to classify, detect, and manage univariate and multivariate outliers, with emphasis on pre-registration. *International Review of Social Psychology, 32*. https://doi.org/10.5334/irsp.289
Leys, C., Ley, C., Klein, O., Bernard, P., & Licata, L. (2013). Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. *Journal of Experimental Social Psychology, 49*, 764–766. https://doi.org/10.1016/j.jesp.2013.03.013
Little, A. C. (2014). Facial attractiveness. *Wiley Interdisciplinary Reviews: Cognitive Science, 5*, 621–634. https://doi.org/10.1002/wcs.1316
Lobmaier, J. S., Fischbacher, U., Wirthmüller, U., & Knoch, D. (2018). The scent of attractiveness: Levels of reproductive hormones explain individual differences in women's body odour. *Proceedings of the Royal Society B: Biological Sciences, 285*, Article 20181520. https://doi.org/10.1098/rspb.2018.1520
Lukaszewski, A. W., Simmons, Z. L., Anderson, C., & Roney, J. R. (2016). The role of physical formidability in human social status allocation. *Journal of Personality and Social Psychology, 110*, 385–406. https://doi.org/10.1037/pspi0000042
Main, J. C., Jones, B. C., DeBruine, L. M., & Little, A. C. (2009). Integrating gaze direction and sexual dimorphism of face shape when perceiving the dominance of others. *Perception, 38*, 1275–1283. https://doi.org/10.1068/p6347
Marečková, K., Weinbrand, Z., Chakravarty, M. M., Lawrence, C., Aleong, R., Leonard, G., … Paus, T. (2011). Testosterone-mediated sex differences in the face shape during adolescence: Subjective impressions and objective features. *Hormones and Behavior, 60*, 681–690. https://doi.org/10.1016/j.yhbeh.2011.09.004
Mehta, P. H., Welker, K. M., Zilioli, S., & Carré, J. M. (2015). Testosterone and cortisol jointly modulate risk-taking. *Psychoneuroendocrinology, 56*, 88–99. https://doi.org/10.1016/j.psyneuen.2015.02.023
van der Meij, L., Almela, M., Buunk, A. P., Fawcett, T. W., & Salvador, A. (2012). Men with elevated testosterone levels show more affiliative behaviours during interactions with women. *Proceedings of the Royal Society B: Biological Sciences, 279*, 202–208. https://doi.org/10.1098/rspb.2011.0764
Miller, J. (1991). Reaction time analysis with outlier exclusion: Bias varies with sample size. *The Quarterly Journal of Experimental Psychology, 43*, 907–912. https://doi.org/10.1080/14640749108400962
Moller, A. P., & Pomiankowski, A. (1993). Why have birds got multiple sexual ornaments? *Behavioral Ecology and Sociobiology, 32*, 167–176. https://doi.org/10.1007/BF00173774
Mondragón-Ceballos, R., Granados, M. D. G., Cerda-Molina, A. L., Chavira-Ramírez, R., & Hernández-López, L. E. (2015). Waist-to-hip ratio, but not body mass index, is associated with testosterone and Estradiol concentrations in young women. *International Journal of Endocrinology, 2015*, Article 654046. https://doi.org/10.1155/2015/654046
Nowak, J., Pawłowski, B., Borkowska, B., Augustyniak, D., & Drulis-Kawa, Z. (2018). No evidence for the immunocompetence handicap hypothesis in male humans. *Scientific Reports, 8*, 7392. https://doi.org/10.1038/s41598-018-25694-0
Oguchi, T., & Kikuchi, H. (1997). Voice and interpersonal attraction. *Japanese Psychological Research, 39*, 56–61. https://doi.org/10.1111/1468- 5884.00037
Pazhoohi, F., Garza, R., Doyle, J. F., Macedo, A. F., & Arantes, J. (2019). Sex differences for preferences of shoulder to hip ratio in men and women: An eye tracking study. *Evolutionary Psychological Science, 5*, 405–415. https://doi.org/10.1007/s10508-022-02416-2
Penton-Voak, I. S., & Chen, J. Y. (2004). High salivary testosterone is linked to masculine male facial appearance in humans. *Evolution and Human Behavior, 25*(4), 229–241. https://doi.org/10.1016/j.evolhumbehav.2004.04.003
Pereira, K. J., da Silva, Havlíček, J., Kleisner, K., Varella, M. A. C., … Valentova, J. V. (2019). Femininity-masculinity and attractiveness–Associations between self-ratings, third-party ratings and objective measures. *Personality and Individual Differences, 147*, 166–171. https://doi.org/10.1016/j.paid.2019.04.033
Peters, M., Rhodes, G., & Simmons, L. W. (2007). Contributions of the face and body to overall attractiveness. *Animal Behaviour, 73*, 937–942. https://doi.org/10.1016/j.anbehav.2006.07.012
Pipitone, R. N., & Gallup, G. G., Jr. (2008). Women's voice attractiveness varies across the menstrual cycle. *Evolution and Human Behavior, 29*, 268–274. https://doi.org/10.1016/j.evolhumbehav.2008.02.001
Pollet, T. V., & van der Meij, L. (2017). To remove or not to remove: The impact of outlier handling on significance testing in testosterone data. *Adaptive Human Behavior and Physiology, 3*, 43–60. https://doi.org/10.1007/s40750-016-0050-z
Pound, N., Penton-Voak, I. S., & Surridge, A. K. (2009). Testosterone responses to competition in men are related to facial masculinity. *Proceedings of the Royal Society B: Biological Sciences, 276*, 153–159. https://doi.org/10.1098/rspb.2008.0990
Preinbergs, J. K., Ström, J. O., Theodorsson, E., & Ingberg, E. (2023). Segmental hair analysis as a retrospective testosterone diary: Possibilities and pitfalls. *Scientific Reports, 13*, 16015. https://doi.org/10.1038/s41598-023-41672-7
Probst, F., Bobst, C., & Lobmaier, J. S. (2016). Testosterone-to-oestradiol ratio is associated with female facial attractiveness. *Quarterly Journal of Experimental Psychology, 69*, 89–99. https://doi.org/10.1080/17470218.2015.102469
Puts, D. A. (2010). Beauty and the beast: Mechanisms of sexual selection in humans. *Evolution and Human Behavior, 31*, 157–175. https://doi.org/10.1016/j.evolhumbehav.2010.02.005
Puts, D. A. (2016). Human sexual selection. *Current Opinion in Psychology, 7*, 28–32. https://doi.org/10.1016/j.copsyc.2015.07.011
Puts, D. A., Apicella, C. L., & Cárdenas, R. A. (2012). Masculine voices signal men's threat potential in forager and industrial societies. *Proceedings of the Royal Society B: Biological Sciences, 279*, 601–609. https://doi.org/10.1098/rspb.2011.0829
Puts, D. A., Hodges, C. R., Cárdenas, R. A., & Gaulin, S. J. (2007). Men's voices as dominance signals: Vocal fundamental and formant frequencies influence dominance attributions among men. *Evolution and Human Behavior, 28*, 340–344. https://doi.org/10.1016/j.evolhumbehav.2007.05.002
R Core Team. (2015). *R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing Retrieved from.* https://www.r-project.org.
Rezlescu, C., Penton, T., Walsh, V., Tsujimura, H., Scott, S. K., & Banissy, M. J. (2015). Dominant voices and attractive faces: The contribution of visual and auditory information to integrated person impressions. *Journal of Nonverbal Behavior, 39*, 355–370. https://doi.org/10.1007/s10919-015-0214-8
Rhodes, G., Zebrowitz, L. A., Clark, A., Kalick, S. M., Hightower, A., & McKay, R. (2001). Do facial averageness and symmetry signal health? *Evolution and Human Behavior, 22*, 31–46. https://doi.org/10.1016/S1090-5138(00)00060-X
Röder, S., Fink, B., Feinberg, D. R., & Neave, N. (2013). Facial visualizations of women's voices suggest a cross-modality preference for femininity. *Evolutionary Psychology, 11*, 227–237. https://doi.org/10.1177/14747049130110011
Roney, J. R. (2016). Theoretical frameworks for human behavioral endocrinology. *Hormones and Behavior, 84*, 97–110. https://doi.org/10.1016/j.yhbeh.2016.06.004
Roth, T. S., Samara, I., & Kret, M. E. (2021). Multimodal mate choice: Exploring the effects of sight, sound, and scent on partner choice in a speed-date paradigm. *Evolution and Human Behavior, 42*, 461–468. https://doi.org/10.1016/j.evolhumbehav.2021.04.004
Russell, E., Koren, G., Rieder, M., & Van Uum, S. (2012). Hair cortisol as a biological marker of chronic stress: Current status, future directions and unanswered questions. *Psychoneuroendocrinology, 37*, 589–601. https://doi.org/10.1016/j.psyneuen.2011.09.009
Saxton, T. K., Burriss, R. P., Murray, A. K., Rowland, H. M., & Craig Roberts, S. (2009). Face, body and speech cues independently predict judgments of attractiveness. *Journal of Evolutionary Psychology, 7*, 23–35. https://doi.org/10.1556/jep.7.2009.1.4
Saxton, T. K., Caryl, P. G., & Craig Roberts, S. (2006). Vocal and facial attractiveness judgments of children, adolescents and adults: The ontogeny of mate choice. *Ethology, 112*, 1179–1185. https://doi.org/10.1111/j.1439-0310.2006.01278.x
Schaefer, K., Fink, B., Grammer, K., Mitteroecker, P., Gunz, P., & Bookstein, F. L. (2006). Female appearance: facial and bodily attractiveness as shape. *Psychology Science, 48*, 187–204.
Schirmer, A., Franz, M., Krismann, L., Nöring, V., Große, M., Mahmut, M., & Croy, I. (2025). Attraction in every sense: How looks, voice, movement and scent draw us to future lovers and friends. *British Journal of Psychology*. https://doi.org/10.1111/bjop.12787
Scott, I. M., Clark, A. P., Boothroyd, L. G., & Penton-Voak, I. S. (2013). Do men's faces really signal heritable immunocompetence? *Behavioral Ecology, 24*, 579–589. https://doi.org/10.1093/beheco/ars092
Smith, H. M., Dunn, A. K., Baguley, T., & Stacey, P. C. (2016). Concordant cues in faces and voices: Testing the backup signal hypothesis. *Evolutionary Psychology, 14*, Article 1474704916630317. https://doi.org/10.1177/1474704916630317
Sorokowski, P., & Kowal, M. (2024). Relationship between the 2D: 4D and prenatal testosterone, adult level testosterone, and testosterone change: Meta-analysis of 54 studies. *American Journal of Biological Anthropology, 183*, 20–38. https://doi.org/10.1002/ajpa.24852
Stephen, I. D., & Luoto, S. (2023). Physical cues of partner quality. In J. K. Mogilski, & T. K. Shackelford (Eds.), *The Oxford handbook of evolutionary psychology and romantic relationships* (pp. 42–73). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197524718.013.2.
Stern, J., Arslan, R. C., & Penke, L. (2022). Stability and validity of steroid hormones in hair and saliva across two ovulatory cycles. *Comprehensive Psychoneuroendocrinology, 9*, Article 100114. https://doi.org/10.1016/j.cpnec.2022.100114
Stern, J., & Casto, K. (2024). Salivary testosterone across the menstrual cycle. *Hormones and Behavior, 164*, Article 105608. https://doi.org/10.1016/j.yhbeh.2024.105608
Stulp, G., Buunk, A. P., & Pollet, T. V. (2013). Women want taller men more than men want shorter women. *Personality and Individual Differences, 54*, 877–883. https://doi.org/10.1016/j.paid.2012.12.019
Swami, V., & Tovée, M. J. (2005). Male physical attractiveness in Britain and Malaysia: A cross-cultural study. *Body Image, 2*, 383–393. https://doi.org/10.1016/j.bodyim.2005.08.001
Tanaka, J. W., Kiefer, M., & Bukach, C. M. (2004). A holistic account of the own-race effect in face recognition: Evidence from a cross-cultural study. *Cognition, 93*, B1–B9. https://doi.org/10.1016/j.cognition.2003.09.011
Thornhill, R., & Grammer, K. (1999). The body and face of woman: One ornament that signals quality? *Evolution and Human Behavior, 20*(2), 105–120. https://doi.org/10.1016/S1090-5138(98)00044-0
Tovée, M. J., Tasker, K., & Benson, P. J. (2000). Is symmetry a visual cue to attractiveness in the human female body? *Evolution and Human Behavior, 21*, 191–200. https://doi.org/10.1016/S1090-5138(00)00040-4
Třebický, V., Delplanque, S., Ferdenzi, C., Fink, B., Jelínková, L., Pátková, Ž., … Havlíček, J. (2023). Cross-modal associations of human body odour attractiveness

with facial and vocal attractiveness provide little support for the backup signals hypothesis: A systematic review and meta-analysis. *Evolution and Human Behavior, 44*, 19–29. https://doi.org/10.1016/j.evolhumbehav.2022.11.001

Tsepelidis, S., Devreker, F., Demeestere, I., Flahaut, A., Gervy, C., & Englert, Y. (2007). Stable serum levels of anti-Mullerian hormone during the menstrual cycle: A prospective study in normo-ovulatory women. *Human Reproduction, 22*, 1837–1840. https://doi.org/10.1093/humrep/dem101

Valentova, J. V., Varella, M. A. C., Havlíček, J., & Kleisner, K. (2017). Positive association between vocal and facial attractiveness in women but not in men: A cross-cultural study. *Behavioural Processes, 135*, 95–100. https://doi.org/10.1016/j.beproc.2016.12.005

Van Dongen, S., & Gangestad, S. W. (2011). Human fluctuating asymmetry in relation to health and quality: A meta-analysis. *Evolution and Human Behavior, 32*, 380–398. https://doi.org/10.1016/j.evolhumbehav.2011.03.002

Watkins, C. D. (2025). Mate assessment based on physical characteristics: A review and reflection. *Biological Reviews, 100*, 113–130. https://doi.org/10.1111/brv.13131

Watts, J. C., & Fitzpatrick, C. L. (2024). The effects of intersexual interactions on survival can drive the evolution of female ornaments in the absence of mate limitation. *Journal of Evolutionary Biology, 37*, 1356–1367. https://doi.org/10.1093/jeb/voae121

Weeden, J., & Sabini, J. (2005). Physical attractiveness and health in Western societies: A review. *Psychological Bulletin, 131*, 635–653. https://doi.org/10.1037/0033-2909.131.5.635

Wells, T., Baguley, T. S., Sergeant, M. J. T., & Dunn, A. K. (2013). Perceptions of human attractiveness comprising face and voice cues. *Archives of Sexual Behavior, 42*, 805–811. https://doi.org/10.1007/s10508-012-0054-0

White, J. D., & Puts, D. A. (2019). Genes influence facial attractiveness through intricate biological relationships. *PLoS Genetics, 15*, Article e1008030. https://doi.org/10.1371/journal.pgen.1008030

Williams, M. N., & Apicella, C. L. (2023). A test of multimodal communication in humans using 881 judgements of men and women's physical, vocal, and olfactory attractiveness. *Heliyon, 9*, Article e16895. https://doi.org/10.1016/j.heliyon.2023.e16895

Williams, T. M., & Carroll, S. B. (2009). Genetic and molecular insights into the development and evolution of sexual dimorphism. *Nature Reviews Genetics, 10*, 797–804. https://doi.org/10.1038/nrg2687

Windhager, S., Schaefer, K., & Fink, B. (2011). Geometric morphometrics of male facial shape in relation to physical strength and perceived attractiveness, dominance, and masculinity. *American Journal of Human Biology, 23*, 805–814. https://doi.org/10.1002/ajhb.21219

Wolff, S. E., & Puts, D. A. (2010). Vocal masculinity is a robust dominance signal in men. *Behavioral Ecology and Sociobiology, 64*, 1673–1683. https://doi.org/10.1007/s00265-010-0981-5

Xia, F., Sauciuvenaite, J., Bissland, R., Hambly, C., Starr-Vaanholt, L., Faries, M. D., … Speakman, J. R. (2025). The relationship between body fatness and physical attractiveness in males. *Personality and Individual Differences, 243*, Article 113240. https://doi.org/10.1016/j.paid.2025.113240

Young, A. W., Frühholz, S., & Schweinberger, S. R. (2020). Face and voice perception: Understanding commonalities and differences. *Trends in Cognitive Sciences, 24*, 398–410. https://doi.org/10.1016/j.tics.2020.02.001

Zaidi, A. A., White, J. D., Mattern, B. C., Liebowitz, C. R., Puts, D. A., Claes, P., & Shriver, M. D. (2019). Facial masculinity does not appear to be a condition-dependent male ornament and does not reflect MHC heterozygosity in humans. *Proceedings of the National Academy of Sciences, 116*, 1633–1638. https://doi.org/10.1073/pnas.1808659116

Zäske, R., Skuk, V. G., & Schweinberger, S. R. (2020). Attractiveness and distinctiveness between speakers' voices in naturalistic speech and their faces are uncorrelated. *Royal Society Open Science, 7*, Article 201244. https://doi.org/10.1098/rsos.201244

Zebrowitz, L. A., & Franklin, R. G., Jr. (2014). The attractiveness halo effect and the babyface stereotype in older and younger adults: Similarities, own-age accentuation, and older adult positivity effects. *Experimental Aging Research, 40*, 375–393. https://doi.org/10.1080/0361073X.2014.897151

Zouboulis, C. C., Chen, W. C., Thornton, M. J., Qin, K., & Rosenfield, R. (2007). Sexual hormones in human skin. *Hormone and Metabolic Research, 39*, 85–95. https://doi.org/10.1055/s-2007-961807